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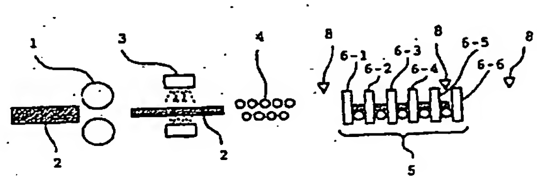
(54) **PRODUCTION METHOD FOR STEEL PLATE AND EQUIPMENT THEREFOR**

(57) The invention relates to a method for manufacturing a steel plate comprising the steps of: hot-rolling a steel slab to a steel plate; quenching or accelerated cooling the steel plate; and tempering the steel plate after quenching or accelerated cooling by a solenoid induction heating unit, wherein the step of tempering is conducted by discontinuously heating the steel plate in two or more cycles to a target temperature. The method of the present invention assures on-line tempering for uniformly heating over the whole thickness direction of steel plate without degrading the productivity and overheating the surface of steel plate to above the target level.

FIG. 1



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Description

TECHNICAL FIELD

[0001] The present invention relates to a method for manufacturing a steel plate, specifically to a method for manufacturing thereof including on-line tempering, and to an apparatus therefor.

BACKGROUND ART

[0002] To attain high strength and high toughness, steel plates having 8 mm or larger thickness are usually manufactured by rapid cooling of the hot rolled steel plates such as quenching or accelerated cooling, followed by tempering.
[0003] In recent years, the quenching or the accelerated cooling is conducted at on-line basis. The tempering, however, is given at off-line basis using a gas combustion furnace, so the tempering needs a long time and significantly lowers the productivity of steel plate.
[0004] For improving the productivity, JP-A-4-358022, (the term "JP-A" referred herein signifies the "Japanese Patent Laid-Open No."), proposes a method for tempering a steel plate, which method uses a quenching unit or an accelerated cooling unit, and a rapid tempering unit using a heating means such as electric heating, induction heating, infrared radiation heating, and atmosphere heating, in the manufacturing line of steel plate, thus heating the steel plate, after direct quenching or accelerated cooling, to a specified temperature at a heating speed of 1°C/sec or more, immediately followed by cooling the steel plate at a cooling speed of from 0.05 to 20°C/sec.
[0005] The method disclosed in JP-A-4-358022, however, applies short time tempering by sudden rapid heating, so the method has problems that the surface temperature of steel plate exceeds the target level and that large temperature difference appears in the thickness direction of steel plate, failing in uniform tempering of steel plate.

DISCLOSURE OF THE INVENTION

[0006] An object of the present invention is to provide a method for manufacturing a steel plate, which method does not degrade the productivity and assures uniform tempering in the thickness direction of steel plate while avoiding the surface temperature of steel plate from exceeding the target temperature, and to provide an apparatus therefor.
[0007] The object is attained by a method for manufacturing a steel plate comprising the steps of: hot-rolling a steel slab to a steel plate; quenching or accelerated cooling the steel plate; and tempering the steel plate after quenching or accelerated cooling by a solenoid induction heating unit, wherein the step of tempering is conducted by discontinuously heating the steel plate in two or more heating cycles to a target temperature.
[0008] The above-described method is realized by an apparatus for manufacturing a steel plate comprising: a heating furnace; a rolling mill; a quenching unit or an accelerated cooling unit; and two or more solenoid induction heating units, in this order beginning from upstream side of the manufacturing process.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009]

Figure 1 shows an example of apparatus for manufacturing a steel plate according to the present invention.
Figure 2A and Figure 2B are the graphs showing the variations in surface temperature and thickness center temperature of steel plate with time, when the steel plate having 8 mm thickness was heated to around 650°C in one and two heating cycles, respectively.
Figure 3 is the graph showing the variations in surface temperature of steel plate with time, when the steel plate having 40 mm thickness was heated to 580°C in six heating cycles.
Figure 4 shows an example of air injection pipe for cooling the width edge sections of steel plate.
Figure 5 shows an example of water spray nozzle for cooling the width edge sections of steel plate.
Figure 6 shows an example of water cooled roll for cooling the width edge sections of steel plate.
Figure 7 is the graph showing the variations in surface temperature and thickness center temperature of steel plate with time, when the steel plate having 50 mm thickness was heated to around 650°C in one heating cycle.
Figure 8 is the graph showing the variations in surface temperature and thickness center temperature of steel plate with time, when the steel plate having 50 mm thickness was heated to around 650°C in four heating cycles.
Figure 9 is the graph showing the variations in surface temperature and thickness center temperature of steel plate with time, when the steel plate having 50 mm thickness was heated to around 650°C in six heating cycles.
Figure 10 is the graph showing the variations in surface temperature and thickness center temperature of steel plate with time, when the steel plate having 20 mm thickness was heated to around 650°C in four heating cycles

by reciprocating the steel plate in a solenoid induction heating unit.

Figure 11 is the graph showing the variations in temperatures at various positions in steel plate with time, when the steel plate having 40 mm thickness was heated to around 650°C in six heating cycles while cooling the edge sections thereof.

EMBODIMENTS OF THE INVENTION

[0010] Figure 1 shows an example of apparatus for manufacturing a steel plate according to the present invention.

[0011] A steel plate 2 which was hot-rolled by a hot-rolling mill 1 is quenched in a quenching unit 3 and flattened by a leveler 4, followed by tempering in a tempering unit 5 having six solenoid induction heating units 6-1 through 6-6.

[0012] During tempering, the steel plate 2 is discontinuously heated to a target temperature around 650°C in two or more heating cycles using a part or whole of the six solenoid induction heating units 6-1 through 6-6 so that the surface temperature should not exceed the target temperature and that the uniform heating should be conducted in the thickness direction of steel plate.

[0013] Figure 2A and Figure 2B are the graphs showing the variations in observed surface temperature at width center section of steel plate and in calculated thickness center temperature thereof with time, when the steel plate having 8 mm thickness was heated to around 650°C in one heating cycle or two discontinuous heating cycles, respectively. In these cases, one heating cycle was conducted using the solenoid induction heating unit 6-1 applying 7.5 MW of power input and 1500 Hz of frequency, and two heating cycles were conducted using the solenoid induction heating units 6-1 and 6-2 applying 4.5 MW (6-1) and 3 MW (6-2) of power input and 1500 Hz of frequency. The travel speed of steel plate was 0.2 m/s for both cases.

[0014] In one heating cycle, the surface of steel plate is overheated above the target temperature. In two heating cycles, however, the surface of steel plate is not overheated, and the surface and the thickness center of steel plate can be heated to the target temperature within short time, around 15 seconds. Consequently, the method according to the present invention assures uniform tempering over the whole thickness direction of steel plate without degrading the productivity and overheating the surface of steel plate. If the thickness of steel plate increases, it takes a long time for thermal diffusion to the thickness center, so the number of heating cycles should be increased depending on the thickness thereof.

[0015] The solenoid induction heating unit is applied as a heating unit because the unit is able to conduct accelerated heating and because the heat generation concentrates on the surface of steel plate, in principle, thus the heating condition may be easily controlled based on the surface temperature.

[0016] If the heating in succeeding cycle is given after the surface temperature of steel plate becomes at or below the mean temperature of thickness direction of steel plate after the preceding heating cycle, discontinuous heating can be conducted more precisely while avoiding the surface temperature from exceeding the target level. The mean temperature of thickness direction of steel plate is a temperature determined in advance by calculation on a given discontinuous heating pattern. Figure 3 is the graph showing an example of heating the steel plate having 40 mm thickness to a target temperature of 580°C in six heating cycles. In this case, since succeeding heating cycle begins before the surface temperature of steel plate becomes the mean temperature of thickness direction thereof, the surface temperature thereof is overheated to above 600°C.

[0017] As shown in Fig. 1, if the leveler 4 is applied to flatten the steel plate before applying tempering, more uniform heating is attained.

[0018] On discontinuously heating the steel plate in plurality of cycles, the power applied to the solenoid induction heating unit and the frequency thereof may be fixed. Nevertheless, it is preferable that these variables are decreased at least in the latter half cycles in view of uniform heating in the thickness direction of steel plate without exceeding the target temperature. Specifically, for bringing the rapidness of tempering higher than the rolling pitch, it is preferable that the applied power is increased as far as possible within the range not exceeding the target temperature, so the power applied in the first half cycles is preferably brought to the maxim level, and the power applied in the latter half cycles is preferably decreased.

[0019] When the frequency of the solenoid induction heating unit is brought to 200 Hz or more, uniform heating is assured over a wide thickness range covering from thin steel plates to thick steel plates. In particular, when the frequency is decreased along with the progress of heating cycles, the penetration depth of induction current becomes large, and more uniform heating in the thickness direction of steel plate is attained. Actually, the penetration depth at 200 Hz of frequency is about 2 mm. For the case of heating the steel plate having 8 mm thickness, when the penetration depth exceeds 2 mm, the temperature control in the thickness direction becomes impossible. Therefore, the frequency has to be 200 Hz or more. Current commercial use frequencies, however, have an upper limit of around 2000 Hz.

[0020] If the total power P applied to the solenoid induction heating unit is determined by eq.(1) given below, the tempering at rapidness at or shorter than the rolling pitch is available, thus giving increased productivity.

$$P \square (1/\eta) \cdot \rho \cdot H \cdot W \cdot L \cdot C_p \cdot (\Delta T/\Delta t) \cdot [(L_c + L_w)/L_c]/L_c] \cdot [1/(N \cdot M)] \ (1) \qquad (1)$$

[0021] where, η is the heating efficiency, ρ is the density of steel (kg/m^3), H is the thickness of steel plate (m), W is the width of steel plate (m), L is the length of steel plate (m), C_p is the specific heat (J/kg°C), ΔT is the necessary temperature rise (°C), Δt is the rolling pitch of steel plate (sec.), L_c is the length of coil (m), L_w is the distance between solenoid induction heating units (m), N is the number of solenoid induction units, and M is the number of heating cycles.

[0022] For example, on heating the steel plate having 40 mm thickness and 12000 kg weight, assuming η=0.7, C_p=600 J/kg°C, ΔT=600°C, Δt=180 sec., L_c=1 m, and L_w=1 m, and if the steel plate travels in one direction through two solenoid induction heating units, the necessary power for one unit thereof becomes 34 MW or more. If three units of solenoid induction heating units are applied to heat the steel plate by traveling thereof by one and a half shuttle, the necessary power becomes 7.6 MW or more. In this manner, eq.(1) is applied to determine the power to carry out the tempering at rapidness at or shorter rolling pitch depending on the number of solenoid induction heating units.

[0023] When a steel plate is heated by solenoid induction heating unit, the steel plate is heated not only from top and bottom surfaces but also from width edge sections, so the width edge sections of steel plate are overheated compared with the width center section. The inventors of the present invention investigated the surface temperature of steel plate in the width direction thereof, and found that a width edge zone corresponding to the thickness of steel plate is overheated by about 1.5 fold compared with the width center section. Consequently, if the tempering is conducted while cooling the width edge sections of steel plate, the overheat at the width edge sections thereof is easily prevented.

[0024] According to the apparatus given in Fig. 1, the leveler 4 is applied to flatten the steel plate before the treatment aiming at the uniform tempering. If a leveler is positioned after the treatment, the steel plate having excellent flatness is manufactured.

[0025] Since the induction heating conducts heating of steel plate by charging energy from the surface thereof, the steel plate likely suffers nonuniform heating in the thickness direction thereof. Accordingly, for soaking, it is necessary to increase the coil length of solenoid induction heating unit as far as possible. If, however, the deflection of steel plate is taken into account, the distance between transfer rolls for supporting the steel plate has a limit of 1.5 m, so it is preferable that the coil length of solenoid induction heating unit is 1. 5 m or less.

[0026] The steel plate is cooled between heating cycles. During the cooling period, thermal diffusion occurs from the surface of steel plate toward the thickness center thereof, thus the uniformizing in temperatures in steel plate proceeds. To establish uniform temperature in steel plate, a time depending on the thickness thereof is required. Since the thermal diffusion rate is almost the same between the heating period and the cooling period, the uniform heating is attained in a wide thickness range covering from thin steel plates to thick steel plates if only the distance between the solenoid induction heating units is kept at least to the coil length.

[0027] According to the apparatus shown in Fig. 1, thermometers 8 are positioned at both inlet and exit of the tempering unit. With these thermometers 8, power applied to and frequency at the solenoid induction heating unit can be controlled. Particularly in the heat treatment of steel plate, since it is necessary to accurately measure the surface temperature of steel plate in view of quality, the thermometer 8 is preferably one dimensional or two dimensional scanning thermometer which can measure the temperature distribution in the longitudinal direction and the width direction of steel plate at a time.

[0028] If a means for cooling is given at inside or exit of the solenoid induction heating unit to cool the width edge sections of steel plate, the overheating at width edge sections can be prevented.

[0029] Examples of the means for cooling are air injection pipe shown in Fig. 4, water spray nozzle shown in Fig. 5, and water cooled roll shown in Fig. 6.

[0030] According to Fig. 4, a pair of ceramics air injection pipes 12a and 12b, having holes 13 (each having 3 mm in diameter) is located facing both width edge sections of steel plate. Air is supplied from air supply pipes 14 to the air injection pipes 12a and 12b, and the cooling air is uniformly ejected from the holes 13 against the width edge section of steel plate. The flow rate of air is controlled by flow regulator valve, thus the cooling capacity is controlled.

[0031] According to Fig. 5, a pair of upper and lower water spray nozzles 16 is located in the vicinity of each width edge section of steel plate between the solenoid induction heating units 6. In addition, air injection nozzles 17 and dewatering rolls 18 are mounted to conduct dewatering to avoid the cooling water ejected from the water spray nozzles 16 from coming near the coil.

[0032] According to Fig. 6, plurality of vertical rolls 19, inside of which is cooled by water, or water cooled rolls 19, are located between the solenoid induction heating units. By pressing the water cooled rolls 19 against respective width edge sections of the steel plate 2, the width edge sections thereof are cooled.

[0033] The condition for cooling the width edge sections by the means for cooling is controlled by determining the

temperature rise curve in the vicinity of width edge sections based on the temperature rise curve near the width center section, which was determined by numerical calculation in advance using the values of width, thickness, and travel speed of steel plate to be treated, in such a way that the temperature at corners of width edge sections should not exceed the target temperature.

[0034] With the tempering unit 5 shown in Fig. 1, the steel plate 2 may be discontinuously heated by moving the steel plate 2 in one direction. Similar heating can be attained, however, by reciprocating the steel plate 2 in the tempering unit 5. Particularly for thick steel plates, discontinuous heating in plurality of cycles is required. However, heating under reciprocating travels of steel plate can reduce the number of solenoid induction heating units. The tempering unit 5 is provided with six solenoid induction heating units. At least two solenoid induction heating units can treat a wide thickness range of steel plates covering from thin steel plates to thick steel plates. Particularly for thin steel plates, two or more of solenoid induction heating units are necessary because the temperature reduction between heating cycles is significant.

Embodiment 1

[0035] With the steel plate manufacturing apparatus shown in Fig. 1, the steel plates 2 having 50 mm thickness, which were hot-rolled by the hot-rolling mill 1, were cooled by water in the quenching unit 3 to 30°C. Each of the cooled steel plates 2 was flattened by the leveler 4, and then was tempered at 650°C under the respective conditions given in Table 1 using six solenoid induction heating units 6-1 through 6-6. The frequency of each solenoid induction heating units was fixed to 1000 Hz.

[0036] Comparative Example used only the solenoid induction heating unit 6-1 to heat the steel plate to 650°C of the surface temperature in one heating cycle. As shown in Fig. 7, the surface temperature became 650°C within 30 seconds, giving the thickness center section temperature of 400°C. After that, both the surface and the thickness center section of the steel plate became around 500°C, not reaching the target temperature of 650°C.

[0037] Example 1 used the solenoid induction heating units 6-1 through 6-4 to heat the steel plate to 650°C of the surface temperature in four heating cycles. As shown in Fig. 8, the surface temperature became 640°C within 200 seconds, giving the thickness center section temperature of 630°C. Thus, the steel plate was almost uniformly heated to the target temperature in. the thickness direction thereof.

[0038] Example 2 used the solenoid induction heating units 6-1 through 6-6 to heat the steel plate to 650°C of the surface temperature in six heating cycles. As shown in Fig. 9, the surface temperature became 650°C within 200 seconds, giving the thickness center section temperature of 640°C. Thus, the steel plate was uniformly heated to the target temperature in the thickness direction thereof.

Table 1

	Travel speed (m/s)	Power applied to induction heating unit (MW)					
		6-1	6-2	6-3	6-4	6-5	6-6
Comparative Example	0.53	10	-	-	-	-	-
Example 1	1.56	10	5	6	3	-	-
Example 2	2.76	10	10	8	8	6	4

Embodiment 2

[0039] With the solenoid induction heating units 6-1 through 6-6, similar with Example 2 of Embodiment 1, steel plates having 50 mm thickness were heated to 650°C of surface temperature in six heating cycles while varying the power applied to and the frequency of each solenoid induction heating unit as shown in Table 2. The travel speed of the steel plates was fixed to 2.76 m/s.

[0040] Also in this Embodiment, almost the same result as in Fig. 9 was attained, giving uniform heating to the target temperature in the thickness direction of steel plate.

Table 2

	Induction heating unit					
	6-1	6-2	6-3	6-4	6-5	6-6
Power input (MW)	10	10	8	8	8	6
Frequency (Hz)	2000	1000	200	200	200	200

Embodiment 3

[0041] With the apparatus for manufacturing a steel plate shown in Fig. 1, the steel plates 2 having 20 mm thickness and 10 m length, after hot-rolled by the hot-rolling mill 1, were cooled by water to 30°C by the quenching unit 3. Each of the cooled steel plates was flattened by the leveler 4, then was traveled by one and a half shuttle through the solenoid induction heating units 6-1 through 6-3. In other words, the steel plate was heated in nine heating cycles to apply tempering at 650°C. The power applied at each heating cycle is given in Table 2. The travel speed of the steel plate was 0.17, 0.30, and 0.30 m/s, respective to the going, coming, and going. The frequency of each solenoid induction heating unit was fixed to 1000 Hz. In shuttle movements, 3 s of stop-interval were adopted between movements.
[0042] Figure 10 is the graph showing the variations in surface temperature and in thickness center temperature of steel plate with time at front end of the longitudinal direction of steel plate.
[0043] Both the surface temperature and the thickness center temperature of steel plate were heated to 650°C almost at the same time.

Table 3

Travel direction	Power applied to induction heating unit (kW)					
	6-1	6-2	6-3	6-4	6-5	6-6
Going	4000	3800	3000	-	-	-
Coming	1800	2200	2500	-	-	-
Going	1000	600	200	-	-	-

Embodiment 4

[0044] With the apparatus for manufacturing a steel plate shown in Fig. 1, the steel plates 2 having 40 mm thickness, after hot-rolled by the hot-rolling mill 1, were cooled by water to 30°C by the quenching unit 3. Each of the cooled steel plates was flattened by the leveler 4, then was tempered at 650°C under the respective conditions given in Table 4 applying the tempering unit 5 having six solenoid induction heating units 6-1 through 6-6. The travel speed of the steel plate was fixed to 0.04 m/s, and the frequency of each solenoid induction heating unit was fixed to 1000 Hz. The air injection pipes shown in Fig. 4 were arranged inside of each of solenoid induction heating units 6-1 through 6-4 and between each neighboring pair of the solenoid induction heating units 6-1 through 6-5 to eject air against the width edge section of steel plate under the conditions given in Table 4.
[0045] Figure 11 is the graph showing the variations in temperatures at four positions in steel plate at 10 m from longitudinal front end of steel plate with time. The four points were namely ① surface at width center section, ② thickness center, ③ a corner at width edge section, and ④ thickness center section.
[0046] At the corner of width edge section, no superheating largely exceeding 650°C occurred, and the temperatures at each observed section increased to 650°C within short time around 200 s.

Table 4

	Induction heating unit						Between induction heating units			
	6-1	6-2	6-3	6-4	6-5	6-6	1-1	2-3	3-4	4-5
Power input (kW)	8000	3000	1400	700	400	250	-	-	-	-
Air pressure (kg/cm^{2}G)	0.3	0.15	0.1	0.08	-	-	0.3	0.15	0.08	0.05
*: Expression "1-2" of the column "Between induction heating units" means the distance between the unit 6-1 and the unit 6-2.										

Claims

1. A method for manufacturing a steel plate comprising the steps of:

 hot-rolling a steel slab to a steel plate;
 quenching or accelerated cooling the steel plate; and

tempering the steel plate after quenching or accelerated cooling by a solenoid induction heating unit,

wherein the step of tempering is conducted by discontinuously heating the steel plate in two or more heating cycles to a target temperature.

2. The method for manufacturing a steel plate of claim 1, wherein heating the steel plate in each heating cycle in the step of tempering begins after the surface temperatures of the steel plate in preceding heating cycle becomes at or lower than the mean temperature in the thickness direction of the steel plate.

3. The method for manufacturing a steel plate of claim 1 further comprising the step of flattening the steel plate between the step of quenching or accelerated cooling and the step of tempering.

4. The method for manufacturing a steel plate of claim 1, wherein the step of tempering is carried out by reducing the entering electric power to the solenoid induction heating unit at least in latter half cycles.

5. The method for manufacturing a steel plate of claim 1, wherein the step of tempering is carried out by reducing frequency of the solenoid induction heating unit at least in latter half cycles.

6. The method for manufacturing a steel plate of claim 1, wherein the step of tempering is carried out at 200 Hz or higher frequency of the solenoid induction heating unit.

7. The method for manufacturing a steel plate of claim 1, wherein the step of tempering is carried out by cooling width edge sections of the steel plate.

8. An apparatus for manufacturing a steel plate comprising: a heating furnace; a rolling mill; a quenching unit or an accelerated cooling unit; and two or more solenoid induction heating units, in this order beginning from upstream side of the manufacturing process.

9. The apparatus for manufacturing a steel plate of claim 8 further comprising a leveler positioned between the quenching unit or the accelerated cooling unit and two or more solenoid induction heating units.

10. The apparatus for manufacturing a steel plate of claim 8 further comprising a leveler positioned at downstream side of the two or more solenoid induction heating units.

11. The apparatus for manufacturing a steel plate of claim 8, wherein individual solenoid induction heating units are located at intervals of coil length or longer distance.

12. The apparatus for manufacturing a steel plate of claim 8 further comprising a means for cooling positioned at inside or exit of each solenoid induction heating unit to cool width edge section of the steel plate.

13. The apparatus for manufacturing a steel plate of claim 12, wherein the means for cooling is the one selected from the group consisting of air injection pipe, water cooled roll, and water spray nozzle.

FIG. 1

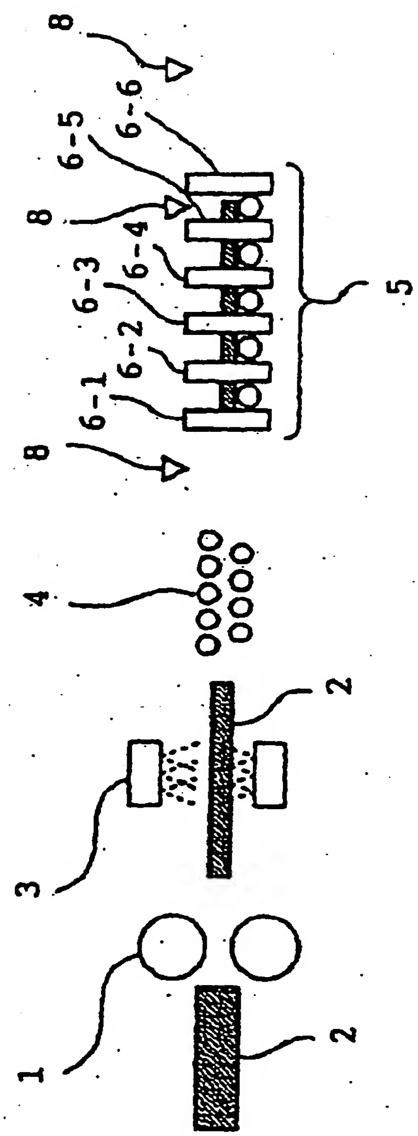
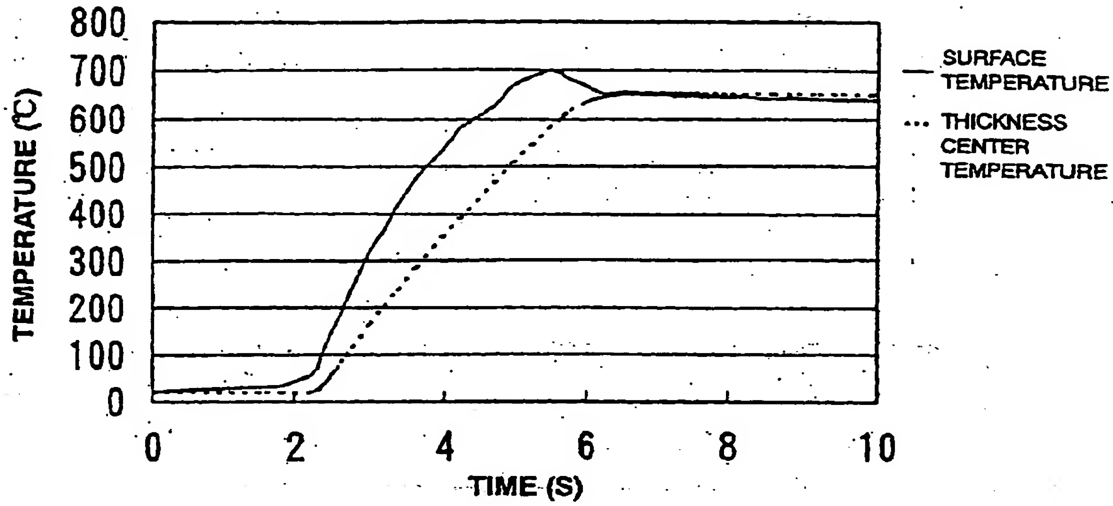


FIG. 2A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SURFACE TEMPERATURE
THICKNESS CENTER TEMPERATURE

FIG. 2B

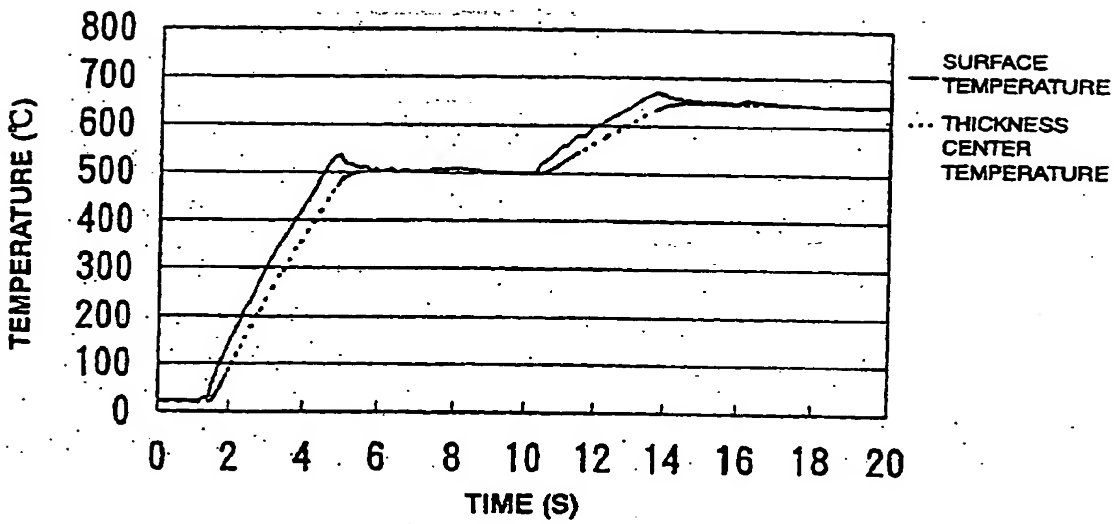
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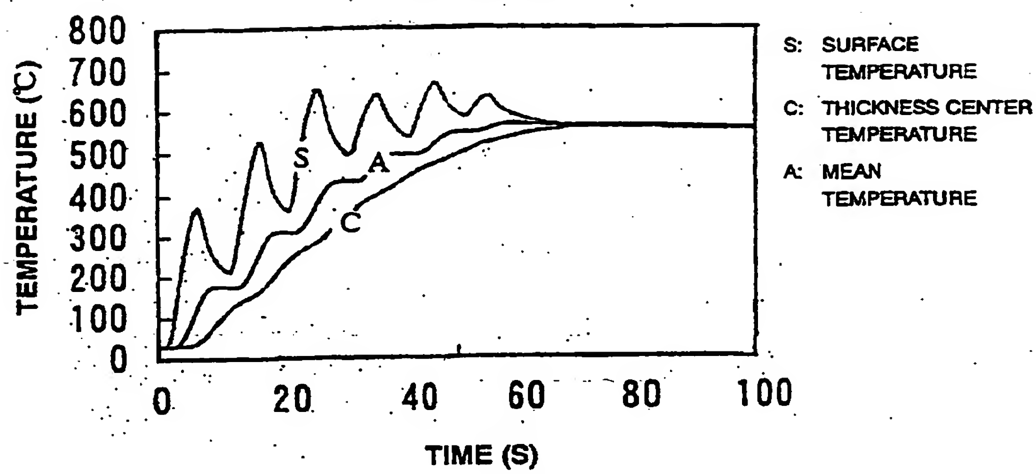
FIG. 3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A: MEAN TEMPERATURE

FIG. 4

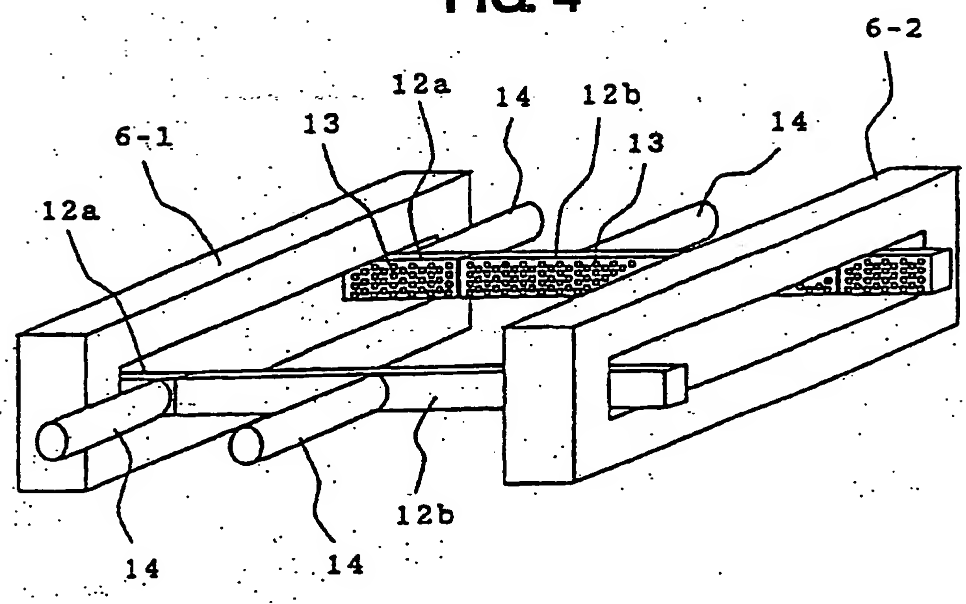
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FIG. 5

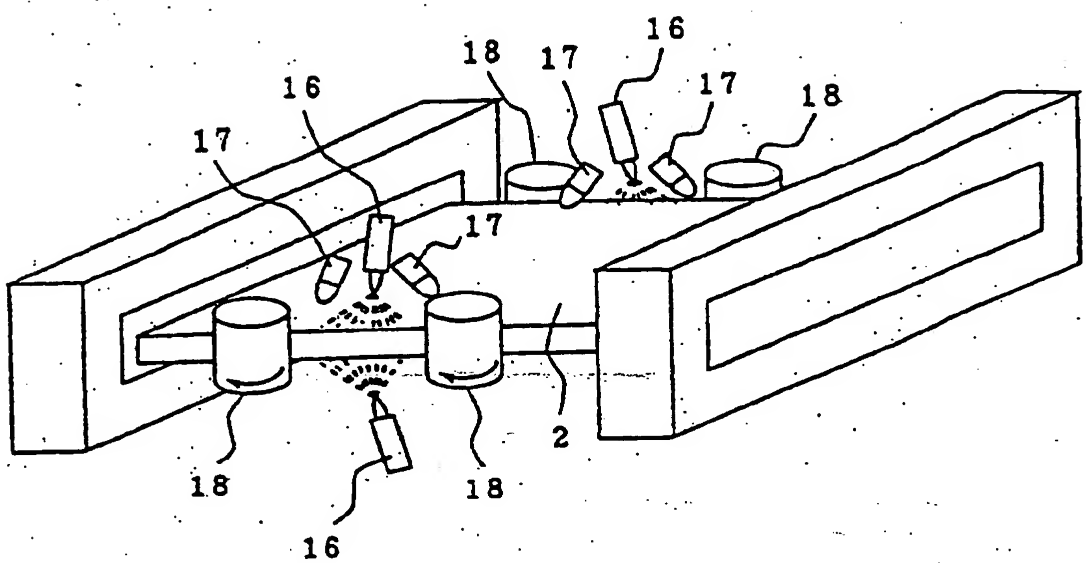

FIG. 6

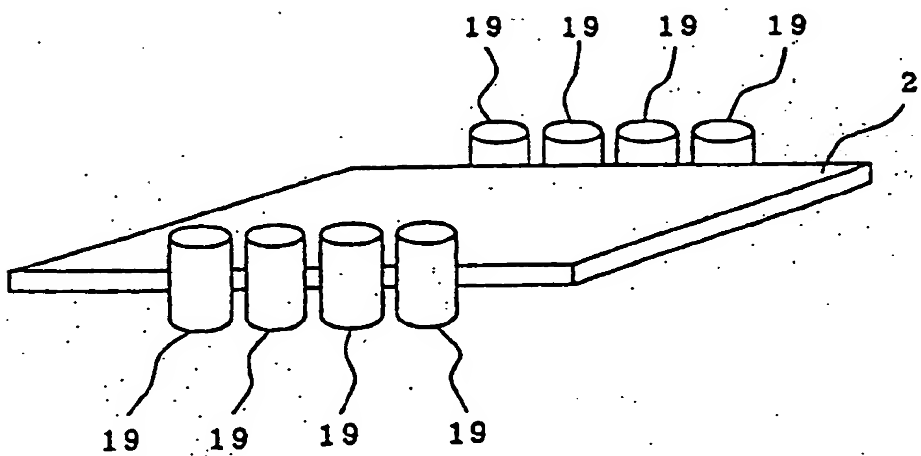

FIG. 7

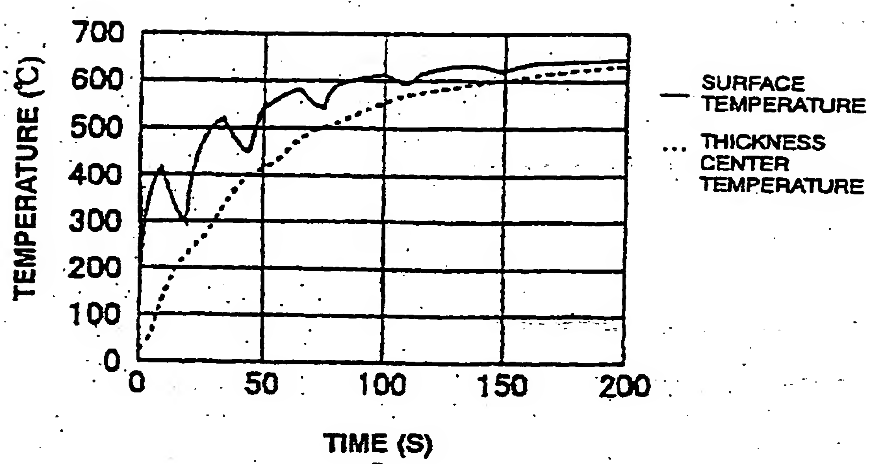
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FIG. 8

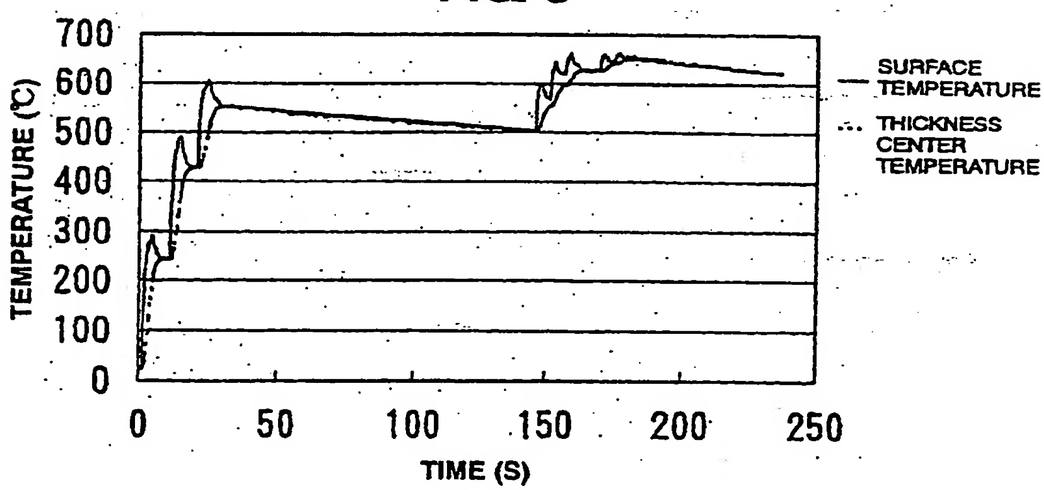
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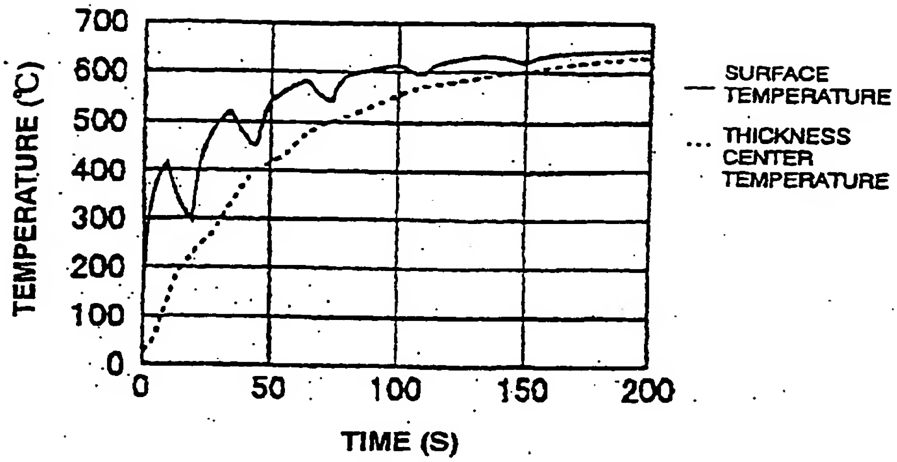
FIG. 9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200
100
0
TEMPERATURE (℃)
0
50
100
150
200
TIME (S)
SURFACE TEMPERATURE
THICKNESS CENTER TEMPERATURE

FIG. 10

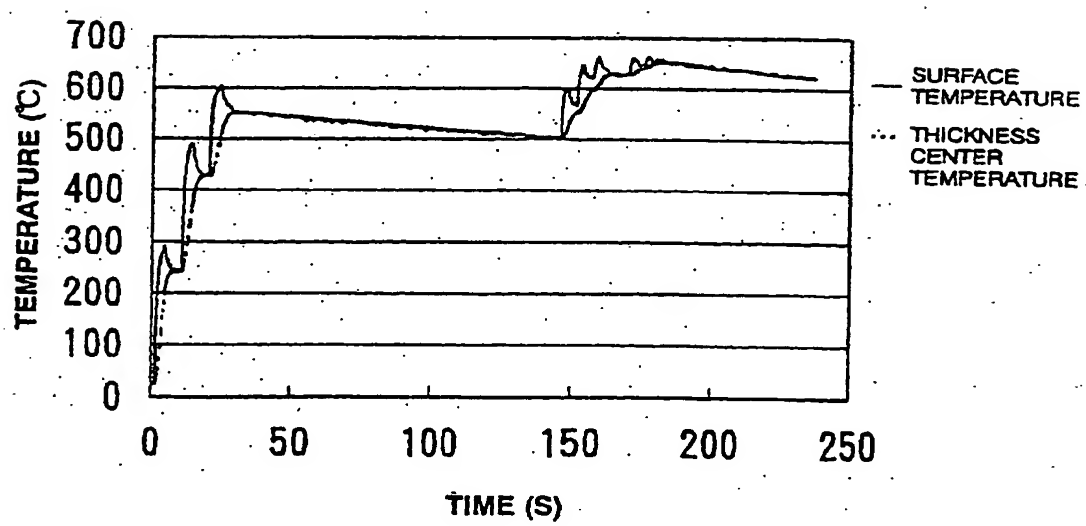
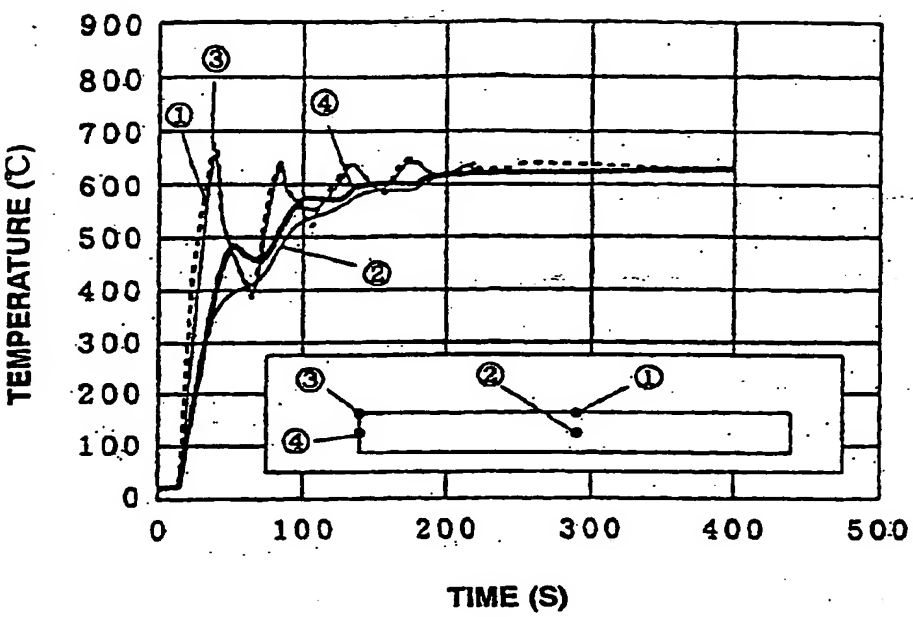

700
600
500
400
300
200
100
0
TEMPERATURE (℃)
0
50
100
150
200
250
TIME (S)
SURFACE TEMPERATURE
THICKNESS CENTER TEMPERATURE

FIG. 11


900
800
700
600
500
400
300
200
100
0
TEMPERATURE (℃)
0
100
200
300
400
500
TIME (S)
①
②
③
④

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP01/11086

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl[7] C21D1/42

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl[7] C21D1/18, 1/42, 8/02, 9/60

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1926-1996	Toroku Jitsuyo Shinan Koho	1994-2002
Kokai Jitsuyo Shinan Koho	1971-2002	Jitsuyo Shinan Toroku Koho	1996-2002

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP, 3015923, B2 (Nippon Steel Corp.), 24 December, 1999 (24.12.99), Claims; Fig. 2 (Family: none)	1,3,6-13 2,4,5
Y A	JP, 51-9176, B2 (Nippon Steel Corp.), 24 March, 1976 (24.03.76), Claims; column 5, line 16 to column 6, line 21; Figs. 2, 4 (Family: none)	1,3,6-13 2,4,5
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility model Application No. 130232/1981 (Laid-open No. 35794/1983). (Sumitomo Metal Industries, Ltd.), 08 March, 1983 (08.03.83), Page 3, line 14 to page 4, line 2; Fig. 2 (Family: none)	3,9

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

* Special categories of cited documents:
- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed
- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "&" document member of the same patent family

Date of the actual completion of the international search 05 March, 2002 (05.03.02)	Date of mailing of the international search report 19 March, 2002 (19.03.02)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP01/11086

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP, 41-16843, B1 (Konan Koshuha Kogyo K.K.), 24 September, 1966 (24.09.66), Claims; page 1, left column, line 26 to right column, line 14; Figs. 1, 2 (Family: none)	10

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